Glass and Ceramics, Vol. 68, Nos. 3 – 4, July, 2011 (Russian Original, Nos. 3 – 4, March – April, 2011)

AT ENTERPRISES AND INSTITUTES

UDC 666.76:666.3.042

IMPROVEMENT OF KILN FURNITURE FOR FIRING CERAMIC ARTICLES

Yu. N. Kryuchkov[1]

Translated from *Steklo i Keramika*, No. 3, pp. 25 – 27, March, 2011.

A technical solution making racks for rolling multitier stacks more efficient for firing ceramics is presented. A rack possesses a horizontal shelf in the form of a quarter-square or -disk and a vertical bearing shape. To increase heat-resistance, decrease mass, and conserve furnace space the shape is hollow with two flat walls joined at 90° and additionally connected by a curvilinear, concave, vertical wall. To increase the effectiveness of the rack and the stability of the stack the rectilinear faces of the rack are equipped at the base with Γ-shaped protrusions vertically oriented along the faces to form scarf joints with similar protrusions on the rectilinear faces of the adjoining supports, while the carrying section of the racks decreases in steps along the vertical position in the stack.

Key words: ceramic articles, improvement, firing, stack, racks, plates, combined rack, scarf joint, effectiveness, heat-resistance.

The placement kiln furniture for firing ceramic articles has a large effect on the cost-effectiveness of the firing process and the quality of the fired articles. For this reason kiln furniture designs are being continually improved [1 – 6].

The most common deficiencies of domestic kiln furniture for multitier firing in stacks is the large mass and inadequate heat-resistance of its elements as well as the existence of substantial bending stresses, which are due to the weight of the upper-lying elements and articles. We shall examine some technical solutions which greatly decrease these deficiencies of kiln furniture placement.

Hollow elements made of heat-resistant steel which are insulated from high temperature by several layers of kaolin or corundum fabric and (or) fiber, wool, and metal tubular screens between the layers can be used to fabricate stacks for firing ceramic materials in chamber and shuttle furnaces. The deformation of the elements at temperatures above 1000°C can be prevented by pumping air (or other coolant) into the elements (heated air can be used to burn fuel or dry molded articles).

A technical solution that increases the carrying capacity utilization efficiency of the racks by making stepped racks is proposed in [6]. The racks have a constant cross-sectional area, decreasing in steps with increasing stack height. This increases considerably the utilization effectiveness of the firing space in the furnace.

We shall now consider a rack in a stack for placing (loading) and firing ceramic articles in a furnace (RF Patent No. 2037762, 2010), made of refractory materials and characterized by high cost-effectiveness and operating reliability with frequent use in a firing furnace.

The rack has a horizontal shelf in the form of a quarter-square plate or disk and a vertical carrying shape, which to increase heat-resistance, decrease mass, and conserve firing space is hollow and consists of two vertical flat walls joined at 90° and additionally joined by a vertical curvilinear concave wall. The flat walls and the curvilinear concave wall of the rack form the lower horizontal bearing surface of the rack (Fig. 1).

To increase the effectiveness of the rack described and the stability of the stack the flat walls of the rack are equipped at its base with Γ-shaped protrusions vertically oriented along the walls so as to form scarf joints with similar protrusions from the flat walls of adjoining supports. The length of the Γ-shaped protrusions is somewhat less than that of the flat walls of the hollow rack frame in order to allow vertical motion and prevent the appearance of additional bending stresses in the plates of the stack. This imparts operational reliability to the stack for placement of ceramic articles with frequent assembly and disassembly of the stack and

[1] Gzhel’ Commercial Art Institute, Gzhel’, Russia (e-mail: yu-kryuchkov@yandex.ru).

0361-7610/11/0304-0095

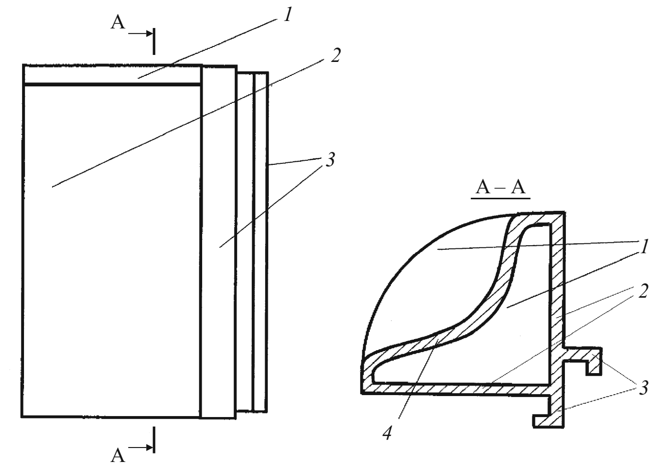

Fig. 1. Rack for holding ceramic articles: *1*) top horizontal shelf; *2*) two vertical flat walls joined at 90°; *3*) Г-shaped protrusions; *4*) vertical curvilinear concave wall.

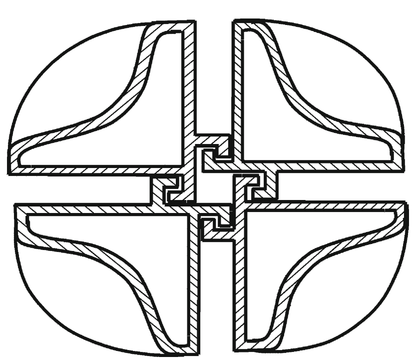

Fig. 2. Combined rack with four racks joined together for holding ceramic articles in a stack.

permits placing the support plates on the horizontally oriented shelves of the racks in the stack. The possibility of duplexing or quadruplexing the racks (Fig. 2) as well as changing the thickness of their walls (this is easily done if they are formed by the pour-off casting method) permits making maximum use of the carrying capacity of the racks (by adjusting the number of racks per plate and the area of the transverse sections of the racks according to their required carrying capacity).

Figure 3 shows the horizontal and vertical sections of a multitier rolling stack based on duplex and quadruplex racks *1* and *2*. The support plates *3* are placed between the racks for holding ceramic articles *4* placed on them. The walls, which are concave along an arc, of the racks make it possible to conserve the plate area for loading articles. In each tier of the stack carrying articles the plates can be installed with a gap (to improve gas transfer, as shown in Fig. 3) or with no gap (forming continuous horizontal surfaces along the surface area of the stack). The bottom of the rack in a shelving unit with maximum wall thickness rests on the bottom plates of the wagon *5* (the bottom row of articles to be fired is placed on these same plates). The thickness of the wall (area of the carrying cross section) of the racks decreases in steps as height increases.

The cross-sectional area $S_{n=1}$ of a rack in the topmost (1st) tier is determined by the expression

$$S_{n=1} = (G_{\mathrm{pl}} + G_{\mathrm{art}})/(\sigma N),$$

where S_n is the transverse section of a rack, m^2; G_{pl} is the weight of a plate, resting on N racks, N; G_{art} is the average total weight of the articles placed on a single plate, N; σ — admissible load on the material of the rack at firing temperature, Pa; N — number of racks per plate.

The cross sectional area S_{n-1} of the second tier from the top is determined similarly:

$$S_{n=2} = [2(G_{\mathrm{pl}} + G_{\mathrm{art}}) + NG_{\mathrm{rack}}]/(\sigma N),$$

where G_{rack} is the weight of the rack, N.

The overall expression for the cross-sectional area of a rack in the nth row (from above) has the form

$$S_n = [n(G_{\mathrm{pl}} + G_{\mathrm{art}}) + (n-1)NG_{\mathrm{rack}}]/(\sigma N).$$

The shelving unit (see Fig. 3) for placing articles is formed using Г-shaped protrusions of two or four adjoining props. Refractory plates are placed on the horizontal shelves

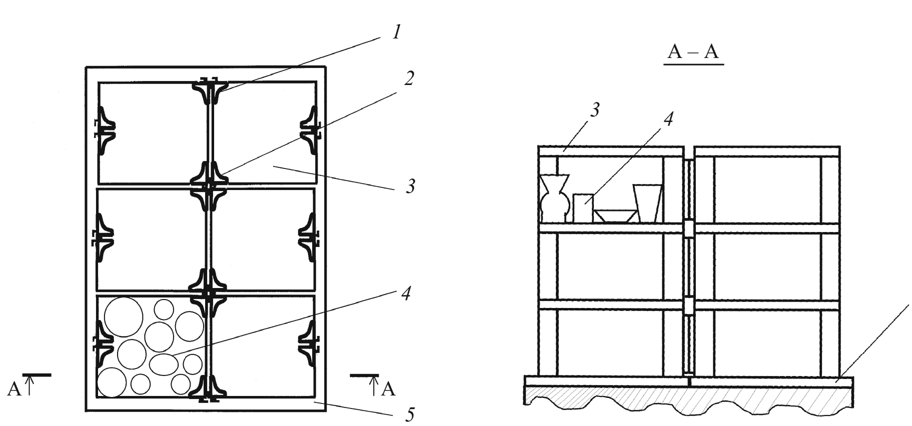

Fig. 3. Stack for holding ceramic articles with support plates between adjoining racks, horizontal and vertical cross sections: *1*) duplex rack; *2*) quadruplex rack; *3*) plate; *4*) article; *5*) beneath the rolling stack.

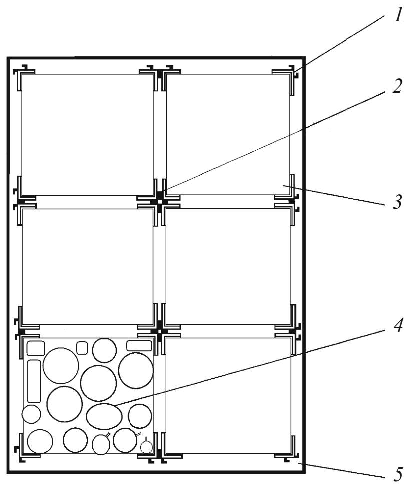

Fig. 4. Variant of a stack with modified racks (no concave walls of the racks): *1*) ordinary rack; *2*) quadruplex rack; *3*) plate; *4*) article; *5*) under the rolling stack.

of the racks and ceramic articles are placed on the shelves. The formation of an assembly-disassembly shelving unit in accordance with Fig. 3 is done on the plates *5* beneath the rolling stack.

It is possible to use modified racks which likewise have a horizontal shelf in the form of quarter-square plate or -disk and a vertical carrying shape, which in order to be able to position articles freely (not cramped by the racks) is a hollow or continuous rectangular shape with Γ-shaped protrusions along the sides (Fig. 4).

The variants of an assembly-disassembly shelving unit shown in Figs. 3 and 4 can be used for heat treatment of ceramic articles in commercial firing furnaces with articles fed into them on rolling stacks.

REFERENCES

1. I. I. Moroz, *Technology of Porcelain-Glazed Earthenware Articles* [in Russian], Stroiizdat, Moscow (1984).
2. Yu. N. Kryuchkov, "Improving the construction of stacks for firing ceramic articles," *Steklo Keram.*, No. 5, 10 – 12 (1995); Yu. N. Kryuchkov, "Improvement of the stack design for firing faience and porcelain ware," *Glass Ceram.*, **52**(5), 112 – 114 (1995).
3. Yu. N. Kryuchkov, "New types of stacks for firing ceramic articles," *Steklo Keram.*, No. 3, 15 – 16 (1996); Yu. N. Kryuchkov, "New types of stacks for firing ceramic articles," *Glass Ceram.*, **53**(3), 76 – 77 (1996).
4. Z. Stavric, "Enegiecinsparung in der keramishen Industrie," *Sprechsaal*, **115**(10), 926 – 931 (1982).
5. D. Berrel, "Secondary kiln furniture for glost firing," *Trans. J. Br. Ceram. Soc.*, **81**(2), 30 – 31 (1982).
6. Yu. N. Kryuchkov, "Optimization of adjustable furnace furniture," *Steklo Keram.*, No. 11, 21 – 22 (1991); Yu. N. Kryuchkov, "Optimizing the design of kiln furniture arrangements," *Glass Ceram.*, **483**(11), 519 – 521 (1991).